PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-034171

(43)Date of publication of application : 31.01.2002

(51)Int.Cl. H02J 7/00
B60L 11/18
H01M 8/00
H01M 8/04
H02J 7/04
H02J 7/10

(21)Application number : 2000-216459

(22)Date of filing : 17.07.2000

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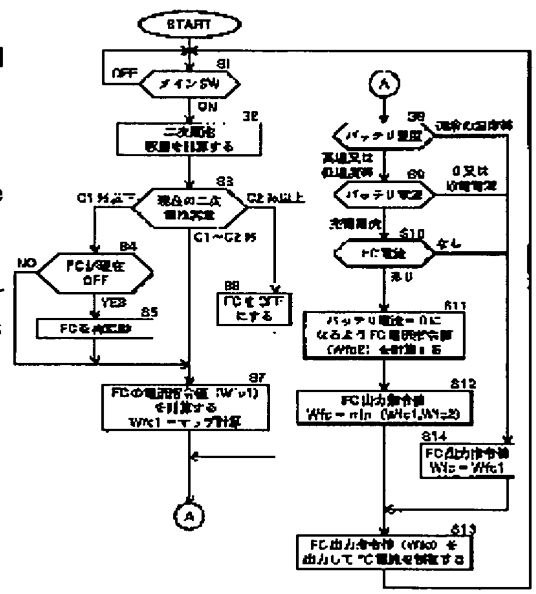
(54) POWER CONTROL METHOD FOR ELECTRIC MOTOR CAR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a power control method for an electric motor car which suppresses characteristic deterioration caused by charging and discharging of the secondary battery and protects the secondary battery in the electric motor car which uses a fuel cell in combination with the secondary battery.

SOLUTION: In the power control method for an electric motor car to be driven by a fuel cell and a secondary battery as power sources, an output command for the fuel cell is set on the basis of the capacity and temperature of the secondary battery.



LEGAL STATUS

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[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

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CLAIMS

[Claim(s)]
[Claim 1] The power control approach of the electric car characterized by setting up the output command value of said fuel cell based on the capacity and temperature of said rechargeable battery in the power control approach of the electric car which uses a fuel cell and a rechargeable battery as a power source.
[Claim 2] When the capacity of said rechargeable battery is more than the predetermined range, the output of a fuel cell is suspended. When said capacity is said predetermined within the limits or the following, the 1st [according to a charge-and-discharge condition] output command value is calculated. The 2nd output command value of a fuel cell is calculated so that the charging current from a fuel cell to a rechargeable battery may not flow, when the temperature of said rechargeable battery is outside the predetermined range. The power control approach of the electric car according to claim 1 characterized by operating a fuel cell with the output command value of the lower one among said 1st and 2nd output command values.
[Claim 3] Said 1st output command value is the power control approach of the electric car according to claim 2 characterized by being the command value of starting or a halt.
[Claim 4] Said 1st output command value is the power control approach of the electric car according to claim 2 characterized by being the command value which changes according to capacity.
[Claim 5] The power control approach of an electric car given in either of claims 1-4 characterized by carrying out drive control of the air pump for a generation of electrical energy of a fuel cell with said output command value.
[Claim 6] The power control approach of an electric car given in either of claims 1-4 characterized by carrying out drive control of the DC to DC converter formed in the output side of a fuel cell with said output command value.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] Especially this invention relates to the power control approach of the electric car which consists of a hybrid power source which combined the fuel cell and the rechargeable battery about the power control approach of an electric car.
[0002]
[Description of the Prior Art] In the electric car using the fuel cell as a power source of the motor for a car drive, while compensating with the power of a fuel cell, in order to raise the responsibility to a demand load, a rechargeable battery is carried in a car with a fuel cell, and the hybrid electric car which drives a motor using these two power sources is developed. Thus, by using a rechargeable battery together, when large power is required, while it mitigates the weight and the volume of a fuel cell which are carried in a car, and coping with it, the responsibility of a fuel cell can be covered.
[0003] In such a hybrid electric car, it considers changing the electric power supply allocation from a fuel cell and a rechargeable battery, and driving a motor at optimal assignment rate corresponding to a load, cell capacity, etc. according to the demand load from a motor. For example, as shown in drawing 10 (A), at the time of the peak load exceeding the maximum electric power of a fuel cell (FC), it compensates with the part to exceed by discharge from a rechargeable battery to the demand load a to change, and a rechargeable battery is charged with the remainder power at the time of below the maximum electric power of a fuel cell. Moreover, power is always supplied to a motor by discharge from a fuel cell and a rechargeable battery, without charging a rechargeable battery, when the demand load a is always over the maximum electric power of a fuel cell as shown in this drawing (B). Moreover, a rechargeable battery is charged with remainder power, a demand load driving a motor only with a fuel cell, when always smaller than the maximum electric power of a fuel cell, as shown in this drawing (C).
[0004]
[Problem(s) to be Solved by the Invention] Thus, as for the rechargeable battery which is used together with FC and repeats charge and discharge, according to a run state, capacity changes during transit. For example, if most outputs of FC are altogether used for charge of a rechargeable battery, and capacity increases them and heavy load operation continues when the car has stopped, a rechargeable battery will always be in a discharge condition, and capacity will decrease.
[0005] Thus, when carrying out charge and discharge to the rechargeable battery from which capacity changes, in order to maintain the performance characteristics of a rechargeable battery good, it is desirable to carry out charge and discharge in the condition in the suitable capacitor range before reaching the upper limit and minimum of capacity. That is, if it charges in the state of high capacity, such as a full charge, or discharges in the state of low capacity, such as a cell piece, conversely, the engine performance of a cell will deteriorate. For example, if high-pressure charge (charge in the high capacity condition) is repeated as shown in the property degradation graph of the rechargeable battery of drawing 9 , a possibility that an electrical potential difference may fall compared with the property of a normal cell, sag when a current increases (at the time of the increment in an output) may fall greatly and early, and the output to need may no longer be obtained will arise.
[0006] Furthermore, the performance characteristics of cells, such as a rechargeable battery, especially a nickel-Cd cell, are influenced by the temperature at the time of charge. For example, if it charges at temperature higher than predetermined temperature or charges at temperature conversely lower than predetermined temperature, it will become the cause which brings degradation of a cell forward.
[0007] This invention aims at offer of the power control approach of an electric car of having controlled

property degradation by the charge and discharge of a rechargeable battery, and having aimed at protection of a rechargeable battery, in consideration of the above-mentioned conventional technique in the electric car which uses a fuel cell and a rechargeable battery together.
[0008]
[Means for Solving the Problem] In order to attain said purpose, in this invention, the power control approach of the electric car characterized by setting up the output command value of said fuel cell based on the capacity and temperature of said rechargeable battery is offered in the power control approach of the electric car which uses a fuel cell and a rechargeable battery as a power source.
[0009] According to this configuration, since the output of a fuel cell is defined based on the capacity and temperature of a rechargeable battery, the output control of a fuel cell can perform a charge-and-discharge operation of the rechargeable battery which changes according to the output of a fuel cell in the state of the optimal capacity and temperature. Thereby, degradation of a rechargeable battery can be controlled.
[0010] In the desirable example of a configuration, when the capacity of said rechargeable battery is more than the predetermined range, the output of a fuel cell is suspended. When said capacity is said predetermined within the limits or the following, the 1st [according to a charge-and-discharge condition] output command value is calculated. When the temperature of said rechargeable battery is outside the predetermined range, the 2nd output command value of a fuel cell is calculated so that the charging current from a fuel cell to a rechargeable battery may not flow, and it is characterized by operating a fuel cell with the output command value of the lower one among said 1st and 2nd output command values.
[0011] According to this configuration, in the state of predetermined high pressure with the rechargeable battery capacity near a full charge, a fuel cell output serves as OFF, and charge is not performed. In below predetermined capacity, the 1st [according to the capacity to a fuel cell] proper output command value is calculated by count. At the time of the elevated temperature exceeding the still more proper temperature requirement to charge and discharge, or low temperature, the 2nd output command value is calculated by count so that a rechargeable battery may not charge from a fuel cell and a fuel cell output may be made lower than the output of a rechargeable battery. By operating a fuel cell with the output command value of the lower one among these 1st and 2nd output command values, the charge to a rechargeable battery from the fuel cell in the outside of the range proper also about the capacity of a rechargeable battery and which conditions of temperature is avoided, degradation of a rechargeable battery is controlled, and protection of a rechargeable battery is achieved.
[0012] In the still more desirable example of a configuration, said 1st output command value is characterized by being the command value of starting or a halt.
[0013] According to this configuration, when a rechargeable battery is below predetermined capacity, if a fuel cell is charged by the rechargeable battery in the state of ON and predetermined capacity is reached until it reaches a predetermined charge, OFF will come and it will discharge. If it discharges, capacity falls and a predetermined value is reached, ON will be again charged by carrying out. Charge and discharge are repeatable in a capacitor range proper thereby always.
[0014] In another desirable example of a configuration, said 1st output command value is characterized by being the command value which changes according to capacity.
[0015] According to this configuration, when a rechargeable battery is below predetermined capacity, if a fuel cell output is made small, corresponding to capacity when there is much capacity, and capacity falls, a fuel cell output can be controlled, the balance of both power sources can be maintained, and it can be used within proper limits so that a fuel cell output may be enlarged. [0016] In the desirable example of a configuration, it is characterized by carrying out drive control of the air pump for a generation of electrical energy of a fuel cell with said output command value.
[0017] According to this configuration, by carrying out drive control of a hydrogen ion and the air pump for oxygen supply made to react for electromotive force generating of a fuel cell, the amount of supply of oxygen is controlled, the output of a fuel cell is controlled, and the charge and discharge of a rechargeable battery are controlled according to this.
[0018] In another desirable example of a configuration, it is characterized by carrying out drive control of the DC to DC converter formed in the output side of a fuel cell with said output command value.
[0019] According to this configuration, by connecting to the output side of a fuel cell the DC to DC converter which changes fuel cell output voltage into a required electrical potential difference, and controlling the output command value of this DC to DC converter, a fuel cell output is controlled and the charge and discharge of a rechargeable battery are controlled according to this.
[0020]

[Embodiment of the Invention] With reference to a drawing, the gestalt of operation of this invention is explained below. Drawing 1 is the block block diagram of the whole power supply unit of the electric car with which this invention is applied. This operation gestalt is the power supply unit of a motor bicycle. The fuel cell (FC unit) 2 and rechargeable battery 3 used as the power source of the motor 1 for a car drive connected with the rear wheel (un-illustrating) of a car are connected with a controller 4 through an interface (IF).
[0021] If the configuration of a fuel cell 2 is explained briefly, this fuel cell 2 will supply the hydrogen used as a fuel to an anode pole, will supply air to a cathode pole as an oxidizer, and will generate electricity by performing electrochemical reaction by the catalyst. Macromolecule ion exchange membrane is infixed between two electrodes. Water is supplied, in order to secure the permeability of a hydrogen ion to this ion exchange membrane and to make it move to it smoothly, and in order to cool generation of heat accompanying an electromotive force reaction. A cel is constituted by making such an electrode pair into a unit, and FC unit of the predetermined output which totaled the electromotive force of each cel combining the cel of two or more sheets is formed.
[0022] By using a methanol as a primary fuel, this is mixed with water, heating evaporation is carried out, the catalytic reaction of a reforming machine decomposes into hydrogen and a carbon dioxide, and the hydrogen used as a fuel supplies this hydrogen gas to the anode electrode of the cel of a fuel cell, after reducing the concentration of the carbon monoxide generated in the minute amount with the reforming vessel through the shift converter, the selective oxidation reactor, etc. Or hydrogen gas may be directly supplied from a bomb.
[0023] The air for a generation of electrical energy is supplied to a cathode pole by the air pump 44. Moreover, hydrogen is supplied from the fuel sources 45 which consist of a hydrogen chemical cylinder or a methanol tank, a reforming machine, etc.
[0024] A fuel cell 2 is equipped with the cooling fan 7 for [for equalization] cooling at the time of a generation of electrical energy whenever [stoving temperature / of the heater 6 for the anti-freeze of the water in FC unit, and this heater 6]. The user switch 8 sets up operation modes, such as for example, the Nighttime charge mode. If a main switch 9 is turned ON, this is detected by the main-switch detecting element 10 in a controller 4, the controller power source 12 and the power source of motor controller 13 grade serve as ON through the system power control section 11, and it will be in the condition which can electric power supply control the whole system by the controller 4.
[0025] At the time of the Nighttime low temperature etc., for the anti-freeze of the water in a fuel cell 2, the timer time amount calculation section 14 computes the timer time amount for driving heater 6 or fuel cell 2 the very thing, even if a main switch 9 is OFF, turns ON a power source through the system power control section 11, and performs pre-heating operation. Based on the detection temperature from the OAT detecting element 16 and the cel temperature detecting element 17, the pre-heating operation control section 18 judges this pre-heating operation, and a heater 6 or a fuel cell 2 is driven through the heater control section 19 or FC output-control section 20. When driving a heater 6, a cooling fan 7 is also driven through the cooling-fan control section 21 for temperature equalization. Moreover, when driving a fuel cell 2, a cooling fan 7 is driven according to cel temperature.
[0026] The motor output count section 22 computes the supply voltage from the throttle opening signal by actuation of a throttle 23 to a motor 1. At this time, a limit is added to the power assignment rate of a fuel cell 2 and a rechargeable battery 3 by the rechargeable battery protection control section 24 according to the remaining capacity and temperature of a rechargeable battery for rechargeable battery protection, this limiting value is considered, and the control signal of a motor is sent to the motor controller 13.
[0027] In charge, the charge condition detecting element 25 distinguishes what is depended on a fuel cell, or the thing to depend on a regeneration current while a rechargeable battery 3 distinguishes a charge condition or a discharge condition. That is, it detects whether while distinguishing the charge direction or the discharge direction by the current detecting element 27, the regeneration current is flowing the current detecting signal from the current sensor 26 of a rechargeable battery 3 to the rechargeable battery side by the current sensor 28 of a motor 1, and a charge condition is distinguished.
[0028] The capacity calculation section 29 controls power allocation of a fuel cell 2 according to delivery and rechargeable battery capacity in FC output-control section 20 while it calculates the capacity of a rechargeable battery 3 based on the detecting signal and current detection data from the electrical-potential-difference detecting element 30 and the temperature detecting element 31 of a rechargeable battery 3 and sends this to the above-mentioned rechargeable battery protection control section 24.
[0029] FC output-control section 20 sends an electrical-potential-difference command value to an air pump

44 through D/A converter 32. This electrical-potential-difference command value controls the power from the fuel cell 2 supplied to a motor 1. In this case, when the abnormalities of a fuel cell, for example, a fuel piece, the abnormalities of cel temperature, etc., occur, that detection data is sent to the abnormality data receive section 33. This abnormality data is sent to FC starting / halt decision section 34 through FC output-control section 20, judges whether the drive of a fuel cell 2 is possible here, and sends out the ON/OFF signal of a fuel cell 2.

[0030] Drawing 2 is the flow chart of the power control approach concerning the operation gestalt of this invention in the power supply of the above-mentioned configuration. This flow chart shows the routine of a control cycle which restricts the output of a fuel cell (FC) based on the capacity and temperature of a rechargeable battery (dc-battery). The actuation of each step is as follows.

[0031] Step S1: Distinguish whether the main switch 9 (drawing 1) is turned on. This is performed by the main-switch detecting element 10 (drawing 1). It stands by until it will be turned on, if it is OFF.

[0032] Step S2: Calculate and calculate the capacity of a rechargeable battery in the capacity calculation section 29 (drawing 1). This is performed by the subroutine of drawing 3 . In this example, a dc-battery current is detected, and capacity is calculated and calculated by integrating this dc-battery current. In this case, the precision of capacity calculated value can be raised by amending the integrated capacity data using the detection data of temperature or an electrical potential difference.

[0033] Step S3: The capacity of the calculated rechargeable battery distinguishes a number of% of maximum capacity. In this example, capacity distinguishes whether it is C1 [suitable] predetermined - suitable predetermined C2% for charge and discharge of within the limits. It is because the discharge not more than C1% and the charge beyond C2% cause degradation of a cell and are not desirable.

[0034] Step S4: When capacity is less than [C1%] (i.e., when discharge is not desirable), distinguish whether FC is operating now. If FC is OFF (a dc-battery discharges), it will progress to step S5.

[0035] Step S5: When FC is current [OFF], this is rebooted and it turns ON. It is for charging a rechargeable battery.

[0036] Step S6: When rechargeable battery capacity is more than C2% (i.e., when charge is not desirable), FC is turned OFF and make it not charge above.

[0037] Step S7: In within the limits with a capacity of a rechargeable battery proper in the range which is C1 - C2%, i.e., charge and discharge, calculate the 1st [to the output of FC] command value (current command value) Wfc1. This count is performed by the map operation shown in the graph of below-mentioned drawing 4 . This output command value Wfc1 is an output command value for power resource to make charge and discharge perform within the limits of [proper] predetermined.

[0038] Step S8: Distinguish whether it is the inside of the predetermined temperature requirement where dc-battery temperature is proper to charge. It is because the dc-battery temperature at the time of charge influences property degradation especially. If it is in a proper temperature requirement, let the output command value Wfc1 calculated at step S7 in the flow of FC load limitation by the above-mentioned capacity be the last output command value (command value which added the limit by capacity and temperature conditions) Wfc of FC (step S14).

[0039] Step S9: In outside the predetermined temperature requirement where dc-battery temperature is proper to charge, if it is flowing while distinguishing whether the current is flowing to the dc-battery, the charge direction or the discharge direction will be distinguished. If it is in a discharge condition, since temperature conditions are satisfactory, they will make the output command value Wfc1 only in consideration of capacity the final output command value Wfc (step S14).

[0040] Step S10: Distinguish whether it is what is depended on a regeneration current from whether it charges with the current from FC in the case of the charge condition, and a motor 1. Since it is charge by the regeneration current when you have no FC current, the charging effect from FC is not performed, therefore the output command value Wfc of FC is set to the above-mentioned Wfc1 only in consideration of capacity conditions (step S14).

[0041] Step S11: When the dc-battery charging current from FC is flowing, FC current command value Wfc2 is calculated so that the current of this charge may become zero. The output command value (current command value) Wfc2 for adding a limit to FC output based on this temperature condition is calculated by PI count by making a dc-battery current detection value and a target dc-battery current value into a function, as shown in the count routine of drawing 5 . The basic type of this PI count is as follows.

Wfc2=G (a dc-battery current detection value, target dc-battery current)
= Multiplier 1* (target dc-battery current) + multiplier 2* (target dc-battery current-dc-battery current detection value)

+ multiplier 3*d(target dc-battery current-dc-battery current detection value)/dT -- the current command value Wfc2 which carried out in this way and was calculated is a command value which added the limit to FC output based on the temperature conditions of a dc-battery.

[0042] Step S12: Let the smaller one be final FC output command value Wfc among the current command value Wfc1 which added the limit to FC output based on capacity, and the current command value Wfc2 which added the limit to FC output based on temperature. Thus, by driving FC with the current command value of the smaller one, it can charge in the proper range also in which conditions by temperature and capacity.

[0043] Step S13: With FC output command value Wfc set up based on temperature and capacity, as shown in below-mentioned drawing 6 , drive an air pump and perform the output control of FC. In this case, as an air pump 44 may be driven through D/A converter 32 from FC output-control section 20 (drawing 1) with a current command value or it is shown in drawing 1 , it may change into an electrical-potential-difference command value, and an air pump may be driven.

[0044] Step S14: When the limit by dc-battery temperature does not need to be added to FC, let the current command value Wfc1 which added the limit by capacity be the final output command value Wfc of FC.

[0045] Drawing 4 is the explanatory view of data processing of Wcfl in the above-mentioned step S7, and (A) and (B) show charge-and-discharge actuation of a respectively different example.

[0046] The approach of drawing 4 (A) makes the output command value Wfc1 of FC either ON or OFF by within the limits whose power resource are C1 - C2%. That is, in the field not more than C2%, as Rhine A1 shows, a current command value charges a dc-battery as a fixed current value i1 corresponding to maximum rated power. If power resource reach to C2%, as Rhine A2 shows, FC will be turned OFF and charge will be suspended. A motor 1 (drawing 1) is driven by discharge of a dc-battery after this. As this shows by Rhine A3, capacity falls. If capacity falls to C1%, as Rhine A4 shows, FC will be started, the current command value wfc1 will be made into the above-mentioned constant value i1, and a dc-battery will be charged. By turning ON FC and charging a dc-battery, discharge is prevented, more than at C2%, FC is turned OFF and the charge to a dc-battery is prevented less than [C1%]. Thus, by repeating ON/OFF of FC by C1 - C2% of within the limits, the charge and discharge in a proper capacitor range are performed, and dc-battery degradation is controlled.

[0047] In addition, it may replace with the approach of turning OFF FC and suspending charge, and a current halt circuit may be formed so that the charging current may not flow from FC to a dc-battery.

[0048] The approach of drawing 4 (B) changes FC output command value (current command value) Wfc1 according to capacity by within the limits whose capacity is C1 - C2%. In this example, as Rhine B-2 shows, the command value is decreased in proportion to capacity. Like the above (A), as Rhine B1 shows, a current command value is i1, charges a dc-battery, more than at C2%, turns OFF FC and prevents charge less than [C1%].

[0049] Drawing 6 (A) shows the control routine of FC current (output) by the air pump in the above-mentioned step S13. A reaction air content is first computed using the map 1 of this drawing (B) from target FC current value (FC output command value Wfc) (step P1). Then, the motor duty corresponding to a reaction air content is computed using the map 2 of this drawing (C) (step P2). The pulse signal of the duty ratio corresponding to this motor duty is outputted, and an air pump is driven (step P3). Thereby, the electromotive force of FC is controlled and the output of FC can be restricted based on the capacity and temperature of a dc-battery as mentioned above.

[0050] Drawing 7 is another operation gestalt whole block diagram of this invention. This operation gestalt performs the output control of FC by connecting DC to DC converter 5 to the output side of a fuel cell 2, and controlling the output of this DC to DC converter 5. That is, although FC output was controlled by the operation gestalt of above-mentioned drawing 1 by carrying out drive control of the air pump 44, the output control of a DC to DC converter performs the output control of FC with the operation gestalt of this drawing 7 . DC to DC converter 5 is output good transformation, transforms the electrical potential difference from a fuel cell 2 into an electrical potential difference required for motorised according to an output command signal, and supplies power to a motor 1. According to operational status, capacity, temperature of a rechargeable battery, etc., the output from a fuel cell can be controlled by this DC to DC converter 5, and, thereby, the charge and discharge of the rechargeable battery can be carried out on a proper capacity and temperature conditions with it. In addition, in drawing 7 , the illustration abbreviation of the air pump for a generation of electrical energy and fuel sources required for FC has been carried out.

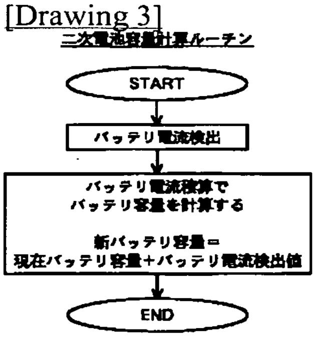
[0051] Drawing 8 shows the routine of the output control of FC by DC to DC converter 5 of drawing 7 . First, the current of FC is detected and the command value of the output voltage of DC to DC converter 5 is

computed as follows by PI count based on this detection value and target FC current value (FC output command value Wfc) (step T1).
DC/DC output voltage =H (FC current detection value, target FC current)
= Multiplier 1* (target FC current)
+ Multiplier 2* (target FC current-FC current detection value)
+ multiplier 3*d(target FC current-FC current detection value)/dT -- thereby, the output voltage command value of a DC to DC converter can be found. This count is performed in FC output-control section 20 (drawing 7).
[0052] Next, an actual signal level is calculated corresponding to the output voltage command value to this DC to DC converter 5 (step T2). As shown in the graph of drawing 8 (B), it is in DC/DC output voltage and proportionality, and this signal level is signal-level = multiplier * (DC/DC output voltage).
It is alike and can be found more.
[0053] This signal level is sent to D/A converter 32 as an electrical-potential-difference command value, and an actual signal level is outputted to DC to DC converter 5 (step T3).
[0054]
[Effect of the Invention] As explained above, since the output of a fuel cell is defined based on the capacity and temperature of a rechargeable battery, by this invention, the output control of a fuel cell can perform a charge-and-discharge operation of the rechargeable battery which changes according to the output of a fuel cell in the state of the optimal capacity and temperature. Thereby, degradation of a rechargeable battery can be controlled.

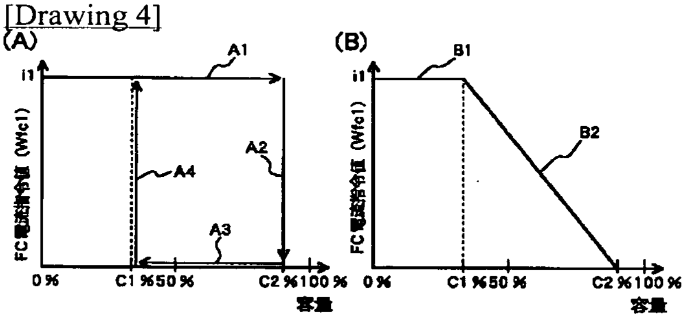
[Translation done.]

DRAWINGS

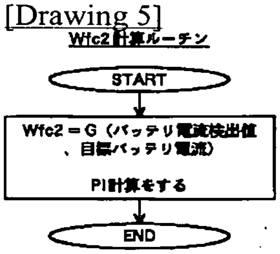
[Drawing 3]



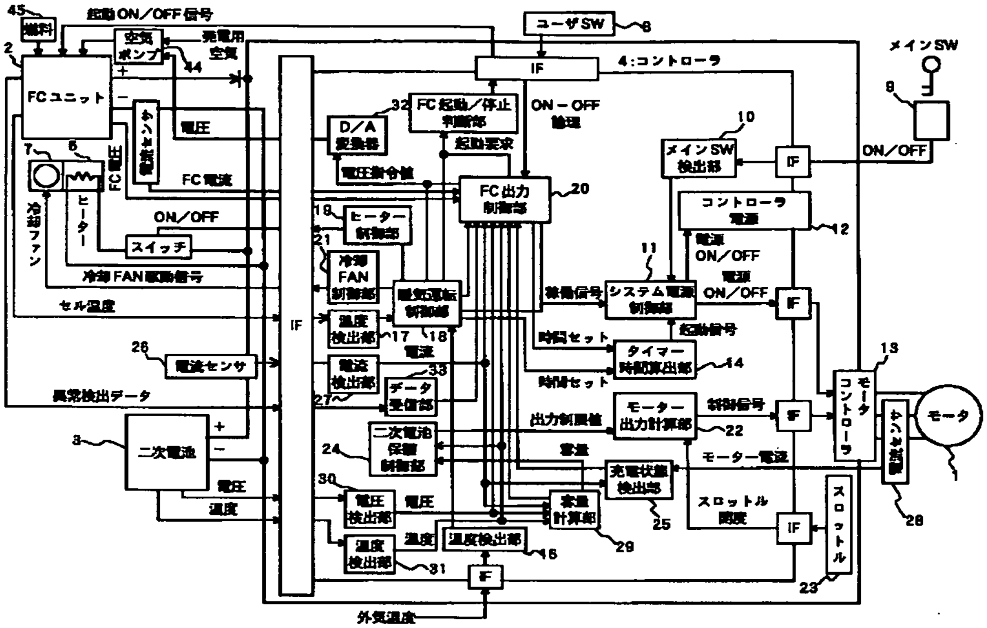
[Drawing 4]



[Drawing 5]



[Drawing 1]



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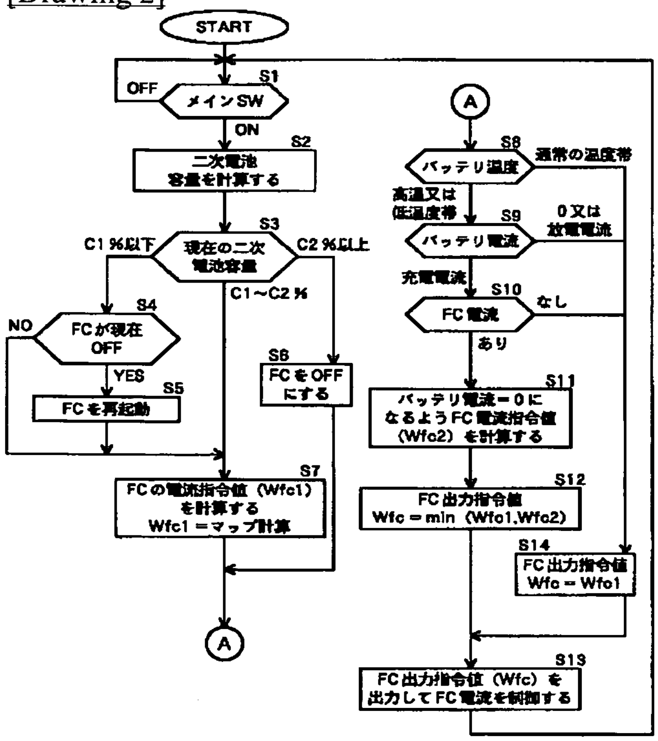
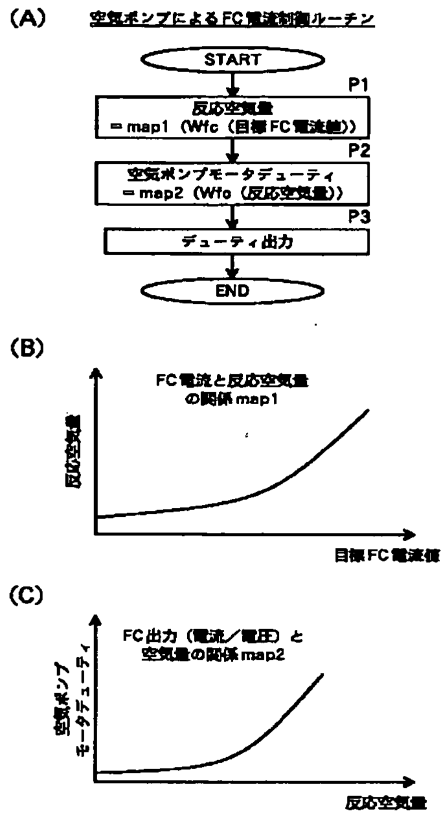


[Drawing 6]



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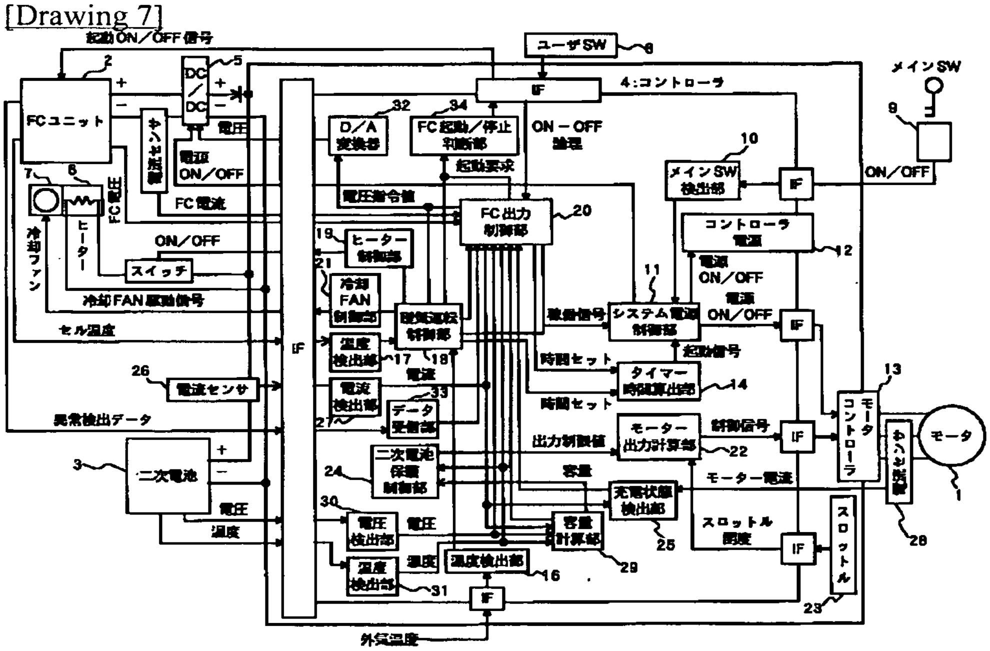
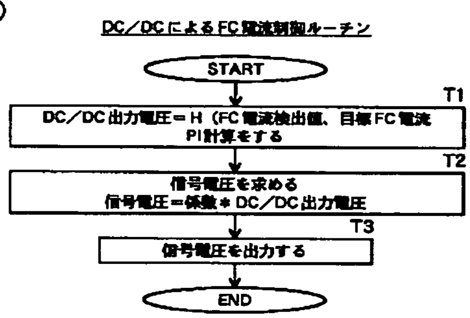


[Drawing 8]

(A)



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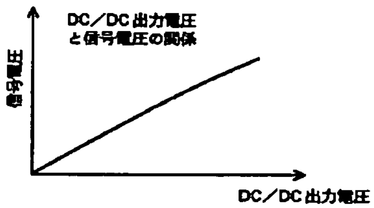
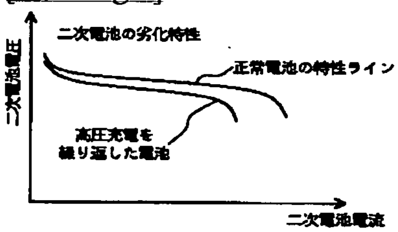
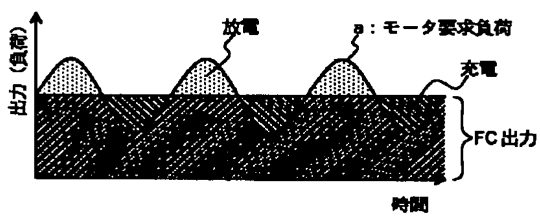


[Drawing 9]



[Drawing 10]

(A)



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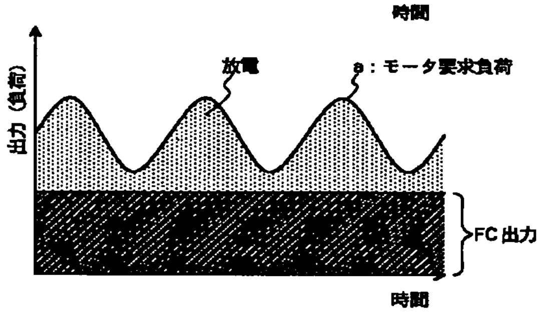

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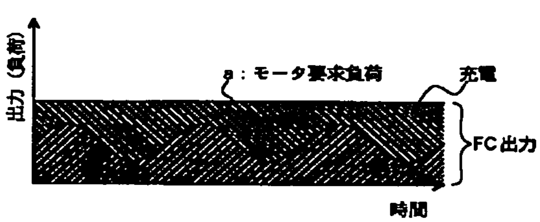

[Translation done.]